



UNIVERSITI PUTRA MALAYSIA

**IMPACTS OF EXPOSURE TO AMBIENT PM₁₀ ON HOSPITAL
OUTPATIENT VISITS FOR HAZE-RELATED DISEASES
AND SCHOOL CHILDREN LUNG FUNCTION**

FARIDAH MOHAMAD

FSAS 2002 23

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By

FARIDAH MOHAMAD

**Thesis Submitted to the Graduate School, Universiti Putra Malaysia, in
Fulfilment of the Requirements for the Degree of Master of Science**

February 2002



Abstract of thesis submitted to the Senate of Universiti Putra Malaysia in
fulfilment of the requirement for the degree of Master of Science

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Chairman : Prof. Madya Dr. Hamdan Hj. Mohd. Noor

Faculty : Science and Environmental Studies

Rapid industrialization and urbanization in Malaysia parallels the worsening air quality in the country. Besides local pollutant emitters, external sources also contribute to aggravate the condition. Haze, or the phenomenon of high air pollution particularly PM₁₀, has become an annual event due to forest fires in a neighbouring country. Exposure to high levels of particulate pollution has long been reported to be detrimental to human health. This study was conducted to determine the relationship between daily PM₁₀ level and daily hospital outpatient visits for asthma, acute respiratory infection and conjunctivitis attended to at HKL and HTAR, Klang from January 1997 (the haze year) to June 1998. Daily air quality and health data were collected retrospectively. Asthma visits were significantly elevated during the haze months. The data were also categorized to produce appropriate contingency tables. Chi-square test revealed significant association between PM₁₀ level and asthma and conjunctivitis, particularly after two to five days lag.

A cross sectional study was performed to investigate the impact of long term exposure to ambient air pollution on the lung function of a total of 780 school children between the age of 16-19 years old in the Klang Valley and Terengganu. The respiratory symptoms were surveyed (questionnaires) and the lung function (VC,FVC and FEV₁) measured using a spirometer. Despite the relatively high pollution level in the Klang Valley, the subjects recorded normal lung function values. However, the lung function values of subjects in the industrial areas of Paka and Kemaman were slightly lower and the respiratory symptoms were more prevalent. Findings from the two studies suggest that asthma and conjunctivitis are associated with PM₁₀ level. However, the types of PM₁₀ pollution (rural/urban/industrial) are important in determining its impact on the exposed population.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia
sebagai memenuhi syarat untuk mendapatkan Ijazah Master Sains

**IMPAK PENDEDAHAN KEPADA PM₁₀ PERSEKITARAN KE ATAS
LAWATAN PESAKIT LUAR HOSPITAL BAGI PENYAKIT-PENYAKIT
BERKAITAN JEREBU DAN FUNGSI PEPARU PELAJAR SEKOLAH**

Oleh

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Perindustrian dan proses perbandaran yang pesat di Malaysia selari dengan kemerosotan kualiti udara di negara ini. Di samping punca-punca tempatan, sumber-sumber luaran juga menyumbang kepada keadaan ini. Jerebu, atau fenomena pencemaran udara yang tinggi terutamanya PM₁₀ kini berlaku setiap tahun akibat kebakaran hutan di negara jiran. Pendedahan kepada pencemaran partikel telah lama dilaporkan membawa kemudaratan kepada kesihatan manusia. Kajian ini telah dijalankan untuk menentukan perkaitan antara paras PM₁₀ harian dengan lawatan ke unit pesakit luar di HKL dan HTAR bagi penyakit asma, jangkitan respiratory akut dan konjunktivitis daripada Jan 1997 (tahun jerebu) hingga Jun 1998. Data kualiti udara dan data kesihatan dikutip secara retrospektif. Lawatan bagi asma meningkat dengan signifikan semasa jerebu. Data juga dikategorikan untuk menghasilkan jadual kontinjensi yang sesuai. Ujian “chi-square” membuktikan terdapat perkaitan yang signifikan antara paras PM₁₀ dengan

dengan bilangan lawatan bagi asma dan konjunktivitis, terutamanya selepas dua hingga lima hari.

Kajian “cross-sectional” juga telah dijalankan untuk mengkaji impak pendedahan jangka panjang kepada pencemaran udara persekitaran ke atas fungsi paru-paru 780 pelajar sekolah (16-19 tahun) di Lembah Kelang dan Terengganu. Simptom respiratori ditentukan melalui soal selidik sementara fungsi paru-paru diukur menggunakan spirometer. Walaupun paras PM_{10} adalah lebih tinggi di Lembah Kelang, semua subjek di semua lokasi kajian menunjukkan fungsi paru-paru yang normal. Walau bagaimanapun, fungsi paru-paru subjek-subjek di Paka dan Kemaman menunjukkan sedikit penurunan, sementara simptom respiratori pula lebih kerap dilaporkan. Daripada kedua-dua kajian di atas, dapat disimpulkan bahawa asma dan konjunktivitis berkait rapat dengan paras pendedahan kepada PM_{10} . Walau bagaimanapun, jenis pencemaran PM_{10} (desa/ bandar/ industri) juga memainkan peranan dalam menentukan impaknya ke atas populasi yang terlibat.

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I certify that an Examination Committee met on 8th February 2002 to conduct the final examination of Faridah Mohamad on her Master of Science thesis entitled "Impacts of Exposure to Ambient PM₁₀ on Hospital Outpatient Visits for Haze-Related Diseases and School Children Lung Function" in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulation 1981. The Committee recommends that the candidate be awarded the relevant degree. Members of the Examination Committee are as follows:

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DECLARATION

I hereby declare that the thesis is based on my original work except for quotations and citations, which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at UPM or other institutions.



(FARIDAH MOHAMAD)

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LIST OF ABBREVIATIONS

$\mu\text{g}/\text{m}^3$	-	Microgram per cubic meter
ARI	-	Acute respiratory infections
ASMA	-	Alam Sekitar Malaysia Sdn. Bhd.
CAQMS	-	Continuous air quality monitoring station
DOE	-	Department of Environment, Malaysia
FEV ₁	-	Forced expiratory volume in one second
FEV ₁ %	-	Percentage of FEV ₁ /FVC
FVC	-	Forced Vital Capacity
HKL	-	Hospital Kuala Lumpur
HTAR	-	Hospital Tuanku Ampuan Rahimah
IMR	-	Institute of Medical Research, KL
KIK	-	Kolej Islam Sultan Abdul Aziz Shah (Kolej Islam Kelang)
MAQG	-	Malaysian Air Quality Guideline
MOE	-	Ministry of Education, Malaysia
MOH	-	Ministry of Health, Malaysia
NMHC	-	Non-methane hydrocarbon
OPD	-	Outpatient department
PM ₁₀		Particulate matter with an aerodynamic diameter less than 10 μm
PM _{2.5}		Particulate matter with an aerodynamic diameter less than 2.5 μm
ppm	-	Part per million
SAS	-	Sekolah Alam Shah
SMPRZ	-	Sekolah Men. (P) Raja Zarina Kelang
SMSS	-	Sekolah Men. Sains Selangor, Cheras
SMT	-	Sekolah Men. Teknik, Cheras
THC	-	Total hydrocarbon
UHPJ	-	Hospital Universiti Petaling Jaya
VC	-	Vital Capacity

CHAPTER 1

INTRODUCTION

Air quality problem has become a major issue in Malaysia for the past two decades. Rapid urbanization and industrialization parallel the worsening air quality in certain areas. Through continuous air monitoring, the Klang Valley has been identified as one of the most polluted regions in the country, particularly for PM₁₀ pollution. Motor vehicles are one of the major sources of pollutants in the area accounting for more than 70% emission on normal days (Awang *et al.*, 1997).

In addition to local sources, Malaysia consistently experiences a series of high particulate pollution due to transboundary sources. Haze or “jerebu” has apparently become an annual event in the country due mainly to forest fires in a neighbouring country. The haze that occasionally occurred during the dry months of August through October, was first detected in the 1960's. The infamous cases prevailed over the last two decades. Significant haze episodes were recorded in 1983, 1984, 1990, 1991, 1994 and 1997 (Awang *et al.*, 1998).

The 1997 haze captured worldwide attention due to its severity and its long persistence of almost four months (July through October). Blankets of dust covered almost every part of the country especially the Klang Valley and Kuching in Sarawak. The air quality was at its worst in September during which an air pollution index (API) of 500 (hazardous

level) was exceeded for more than 24 hours in Kuching. It led to the declaration of an "emergency" state in Sarawak for ten days commencing on 19th September 1997. The pollution level that was more than 8-fold higher than the Malaysian Air Quality Guidelines, MAQG (DOE,1989) was the highest ever recorded in Malaysia since 1977 (Awang *et al.*,1998).

The el-Nino phenomenon that was prevalent during the 1997 haze was believed to be partly responsible for increasing the magnitude. Coupled with normal agricultural activities, the el-Nino synergistically triggered gigantic forest fires that tend to get out of control, especially in Kalimantan and Sumatera. Other meteorological factors played important roles in transporting the particles across national boundaries.

Exposure to high levels of PM₁₀ pollution during severe air pollution episodes worldwide had been clearly associated with adverse health effects on human (Schwartz,1994; Mazumdar *et al.*, 1982; Schimmel and Murawski,1976; Schwartz and Dockery,1992a; Zenz,1993). The industrial air pollution disaster in the Meuse Valley, Belgium in 1930 killed 63 people and caused more than 6000 to become violently ill during a two-day episode. In 1948, a similar case occurred in Donora, Pennsylvania killing 20 people. More than 5000 morbidity cases were also recorded during the very few days of the episode (Waldbott,1975; Zenz,1993). In 1952, the London fog caused 4000 deaths in England. Applications for hospital admissions for respiratory diseases tripled, while cases of respiratory diseases rose 9.5 fold (Schwartz,1994).

In all the three cases mentioned above, respiratory illnesses were found to be among the major diseases and symptoms that led to increased morbidity and mortality (Schwartz, 1994; Waldbott, 1975; Zenz, 1993).

During the 1997 haze, the Malaysian Ministry of Health (MOH) reported a distinct increase in the number of respiratory cases in the Klang Valley. During the first week of September, Hospital Kuala Lumpur (HKL) alone attended to more than 6000 cases of acute respiratory infection (ARI) and 1100 and 500 asthma and conjunctivitis cases respectively (Massa, 1997). Those illnesses were reported to have risen more than two-fold in Kuching, Sarawak (Iylen, 1998).

Besides the extreme exposure during severe air pollution episodes, it had recently been proven that long-term exposure to air pollutants even within the safety guidelines might also lead to adverse impacts on human health. Higher prevalence of respiratory symptoms and reduced lung function were observed within the population living in areas with higher level of pollutants compared to a relatively cleaner area (Linn *et al.*, 1996; He *et al.*, 1993).

The concern of the adverse health effects of air pollutants had led to continuous monitoring of ambient air quality in Malaysia. Health endpoints of air pollution exposure including number of hospital visits for related diseases were selected for the purpose of analysis.

Besides respiratory illnesses, there are numerous observations of an association between exposure to high pollution with reduced lung functions in all ages (Shy,1979; Bates,1980; Ware *et al.*,1981; Schwartz,1994). Lung function had been proven to be a good indicator of the health impacts of exposure to air pollution (Schwartz,1994). However it gains little interest from local scientists and epidemiologists.

The worsening air quality coupled with the annual haze phenomena and the increased number of related diseases during episodes of high pollution days had indicated the need for more studies to be carried out regarding public health in the near future. The epidemiological information that will be gained from the studies, if made transparent to the community, would increase public awareness towards the issue. It would assist in the formulation of new policies, if necessary, in order to protect the public.

The observed health effects associated with ambient air pollution include increased hospital visits for respiratory diseases, increased respiratory symptoms and decreased lung function. Compared to early studies that focussed on severe air pollution episodes, recent studies are more relevant to understanding the health effects of pollution at levels within the standard limits (Pope *et al.*,1995).

This study was carried out in an attempt to discover if the observations mentioned earlier are applicable to the Malaysian condition. The study investigated the acute effects of exposure to extreme air pollution level (PM_{10}) during the 1997 haze episode on human health. The relationship between daily level of air pollution, particularly PM_{10} , and the number of hospital visits for three haze-related diseases namely asthma, ARI and conjunctivitis was determined. This study also attempted to reveal the relationship between long-term exposure to different ambient air pollution levels on human health. This was done by measuring the lung functions and quantifying the respiratory symptoms of school children in four areas of different air quality levels.

The objectives of this study are:

- i. To determine the association between daily PM_{10} levels and daily hospital visits for haze-related diseases namely asthma, ARI and conjunctivitis in the Klang Valley.
- ii. To investigate the impact of long-term exposure to ambient air pollution on lung function and prevalence of respiratory symptoms of school children in four areas of different air quality levels.

CHAPTER 2

LITERATURE REVIEW

2.1 Air quality in Malaysia

2.1.1 Introduction

Following rapid urbanization and industrial expansion over the last few decades, Malaysia is now facing a problem of increasing air pollution (Sham *et al.*, 1991). As technology advances and populations increase, it has become more serious especially in densely populated urban areas. Therefore, no country, including Malaysia, can afford to neglect the problem for long without suffering serious consequences (Kirov, 1979). It is not only a community problem, but is instead of global concern because air pollution recognize no national boundaries. For that reason, the country experiences annual haze phenomena mainly due to forest fires in a neighbouring country (Kirov, 1979; Awang *et al.*, 1998).

The era of air pollution studies in Malaysia began in the 1970's. Being the most urbanized and industrialized area, Petaling Jaya became the favourite spot of such studies besides some other towns. During the early years, the approach was more source-based i.e. relating the air quality with the potential sources and inventorying the pollutant emitters. Some approached the problem from the meteorological point of view. But it was not until very recently that researches were focussed on a more important aspect of air pollution that is the adverse impacts on human health.

2.1.2 History

The earliest formal record of air quality status in Malaysia was in 1972. The report stated that the level of air pollution in the country then was very low, even in all industrial sites (Chen, 1972). In 1973, the first Global Environmental Monitoring System Project launched by the World Health Organisation (WHO) required every participating country to identify a local agency as a focal point to carry out the project at the national level (Kirov, 1979). In 1974, the Malaysian Division (later known as 'Department') of Environment (DOE) was formed to carry out the task (Goh, 1979a). Since the formation of this division, more effort was geared towards managing air quality in Malaysia.

The government also took some important steps in order to control and abate the deteriorating air quality in the country. It began with the passing of the Environmental Quality (Clean Air) Act 1974 with the aim of controlling the location of new industrial facilities with respect to residential areas, the burning of wastes, the emission of dark smoke from chimney stacks and the emission of air impurities. Motor Vehicles (Control of Smoke and Gas Emission) Rules 1977 that aimed to control the emission of dark smoke particularly from diesel-powered vehicles followed later. In 1978, the Environmental Quality (Clean Air) Regulation was passed.